

Search for and Characterization of Galactic Open Clusters with 2MASS

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Abstract. We have developed a star-counting algorithm and tested it on the 2MASS star catalog to search for density enhancements significantly above the field in Galactic latitude $|b| < 50^\circ$. Nearly 500 open clusters are “rediscovered”, along with 89 globular clusters, 35 galaxies, 55 galaxy clusters, 11 H II regions, and 4 regions contaminated by nearby bright stars. Fifty-two density enhancement regions remain unaccounted for. Here we present one such candidate HDG 01, $(\ell, b) = (144.9038, 0.4338)$ which has an angular size of $3'$, a distance of 1.5 kpc, hence a physical size of 3.7 pc. Due to some nebulous shape, this star cluster should be a young-aged (≤ 10 Myr).

1. Introduction

It is estimated that some 10^5 Galactic open clusters (OCs) should exist in the Milky Way Galaxy [9]. However, recent OC catalogs [3, 2, 1, 4, 8, 5] list only a few thousands entries, mainly within 1 kpc. The discrepancy is due partly to the dust extinction in the Galactic plane, and partly to lack of comprehensive all-sky searches.

“Star counting” is an efficient algorithm to identify star density enhancement on a wide-field or an all-sky survey [11]. Several existing all-sky survey databases can be used to identify star density enhancements as OC candidates. For instance, the 2MASS point-source catalog [10] provides a uniformly calibrated database of the entire sky. Furthermore, infrared observations allow us to recognize OCs even with moderate dust extinction, i.e., partially embedded, young star clusters. Recent work by [1], [4] and [5] have indeed found hundreds of previously unknown infrared clusters with 2MASS, some of which turn out to be bona fide stellar groups as verified by follow-up photometric studies. Here we report the results of our searching algorithm and preliminary characterization of star clusters from 2MASS data.

2. Data Analysis: Star Counting Algorithm

The analyzed sky coverage was between Galactic latitude $|b| < 50^\circ$. We divided the sky into $2^\circ \times 2^\circ$ fields and selected 2MASS stars with $S/N > 5$ in all JHKs bands. Each field was analyzed by counting the number of stars in a grid, whose size was chosen to include an average of 10 stars. The same field then would be analyzed again by shifting half a grid size. The resulting density distribution

was then smoothed with a 3×3 box. The background density was estimated by 3σ clipping of outliers. Any grid in the smoothed density map above 5σ background was considered to be a high density grid and a group of more than three adjacent high density grids would be identified as a high density group (HDG). Our analysis resulted in a total of 720 HDGs.

Using the SIMBAD database, we matched the HDGs within a radius of $5'$ with 668 known objects, including 474 OCs, 89 globular clusters, 35 galaxies, 55 galaxy clusters, 11 H II regions, and 4 regions contaminated by nearby bright stars. A total of 52 HDGs remain unaccounted for. These are our OC candidates. In Figure 1, we demonstrate such a case, HDG 01 at $(\ell, b) = (144.9038, 0.4338)$, located near the Galactic plane.

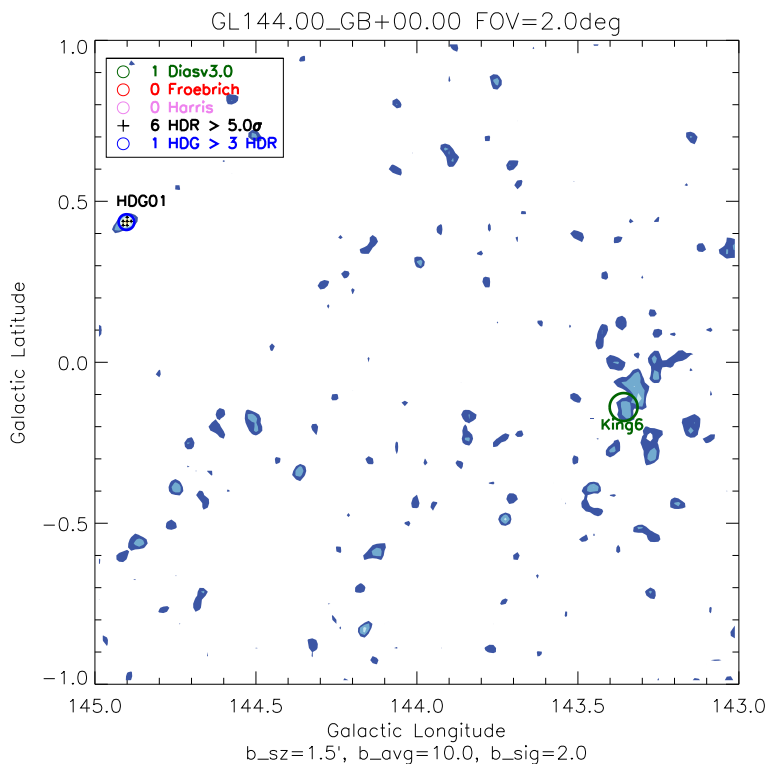


Figure 1. Demonstration of a high density group, HDG 01. The contour marks the the 3σ level above the sky density. Known OCs (in green circles) are from [2] version 3.0. Note that [5] and [6] catalogs were not found in this FOV. Each black plus represents a high density grid and a blue circle marks a HDG.

3. Characterization with 2MASS

Figure 2 shows our analysis of HDG 01 in Fig. 1. The radial density profile suggested a field density of 4.05 ± 1.07 stars per square arcmin, and a density enhancement within $3'$. The central density in the cluster region reaches 26.66 ± 8.11 stars per square arcmin, and there are a total of 51 candidate member stars within the $3'$ cluster radius.

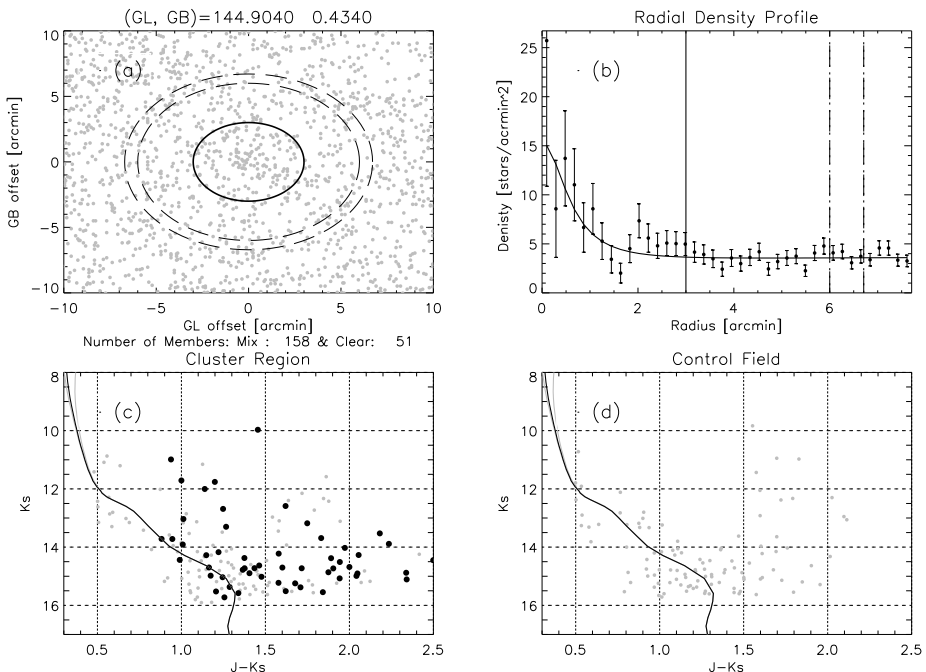


Figure 2. Analysis of HDG 01 in Fig. 1. (a) shows the spatial distribution of 2MASS sources. (b) shows the radial density profile fit with a King’s model (thin curve). The thick line marks the apparent boundary of the cluster, $3'$, and the dashed lines delimit a field region twice the radius away, having the same sky area as the cluster region. The boundaries of the cluster and field regions are shown in (a) by a thick solid circle, and thin dashed circles, respectively. (c) The color-magnitude diagram of HDG 01, for all (in gray) 2MASS sources within the cluster region, i.e., with a radius $< 3'$, and those within $1.5'$ (in black) thus having a higher probability being member stars. (d) The same color-magnitude diagram for the field region, i.e., with a radius $> 6.0'$. The solid line is the isochrone of $\log(t) = 7.0$ yr eye-fitted to the HDG 01 members. Dashed lines are $\log(t) = 6.7$ and $\log(t) = 7.5$ yr, respectively, for reference. The distance modulus is 1.5 ± 0.5 kpc.

The age and distance of NDG 01 are derived by fitting Padova 2MASS photometric isochrones with solar metallicity¹. The best fit, as judged by eye, gives a distance of 1.5 ± 0.5 kpc. At this distance, the cluster’s apparent angular radius of $3'$ corresponds to a physical radius of 3.7 pc. With no kinematic information, particularly for giant stars to constrain the isochrone, the age of HDG 01 is very uncertain. Due to some nebulous shape around this region, it should have an young-age, less then 10 Myr.

4. Summary

We have developed a star counting algorithm and tested it on the 2MASS star catalog to search for candidate star clusters. Within the Galactic latitude

¹ <http://stev.oapd.inaf.it/cmd>

$|b| < 50^\circ$, some 80% overdensity regions are associated with known star clusters, or other objects (galaxies or clusters of galaxies), and a total of 52 uncharted cluster candidates have been found. Here we present one such candidate, HDG 01 at $(\ell, b) = (144.9038, 0.4338)$, with nearly 80 member candidates with an angular radius of $3'$, and at a heliocentric distance of 1.8 kpc. The full analysis will be presented elsewhere. Our algorithm will be applied to other sky survey catalogs such as the Pan-STARRS, which reaches much fainter brightness limits (22–23 mag in r') than those of 2MASS. We expect to enlarge the known OC sample to a much larger space volume in the solar neighborhood and down to significantly lower stellar mass than data currently available. In the third and fourth quadrants, in particular, where the extinction is relatively low, we will be able to explore the entire Milky Way disk, thereby providing a comprehensive sample of OCs to probe the formation and evolutionary history of the Galactic disks.

This work is supported by the grant NSC98-2917-I-008-103 of the National Science Council of Taiwan.

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